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Sound Pressure Level Calibrator

The invention relates to a sound pressure level calibrator in accordance with the preamble of Claim 1.

The calibration of sound pressure level sensors is generally carried out with commercially available sound pressure level calibrators that can produce a maximum sound pressure of 94 dB or 124 dB. To measure sound pressure levels, calibration must be conducted with levels that are nearly as high as the levels to be measured in order to achieve the required measuring accuracy and to be able to check the required dynamics of the recording device of the measuring chain, e.g., a tape recorder, for optimum level control of the recording device. The sound pressure level of commercially available sound pressure level calibrators, which is limited in height, cannot always meet these requirements.

Furthermore, the sound pressure level calibrators of the prior art require the removal for calibration of the sound pressure level sensor from its supporting structure to adapt it to the commercially available sound pressure level calibrators. In prolonged measuring tests with frequent calibration processes, this required removal is very time-consuming and labor intensive. The frequent installation and removal also involves the risk that the sensitive sound pressure level sensor may be damaged.

The object of the invention is to provide a sound pressure level calibrator that is suitable for sound levels to be measured in excess of 124 dB and that can be adapted to the installed sound pressure level sensor.

This object is attained by the invention by the features of Claim 1. Further embodiments of the invention are set forth in the dependent claims.

The solution according to the invention is based on a high-pressure adapter on a commercially available pistonphone, which advantageously acoustically amplifies the

sound pressure emitted by the pistonphone to values > 150 dB and permits the in situ calibration of the sound pressure level sensor.

This makes it possible to conduct calibration in situ immediately prior to the start of the measuring process on the entire measuring chain and to take measurements with relatively high accuracy even if the sound pressure levels are high. In addition, the adapter advantageously permits the calibration of different sound pressure level sensors through adaptation modules.

With reference to the drawing, an exemplary embodiment of the invention will now be described in greater detail. The figure is a schematic sketch of the sound pressure level calibrator according to the invention.

The sound pressure level calibrator depicted in the figure comprises a pistonphone 1, a high-pressure adapter 2 connected to the output of the pistonphone, and a sound pressure level sensor 3.

The pistonphone 2 has a piston 4 for producing sound pressure and an adjustable pistonphone volume 5. The high-pressure adapter 2 comprises a $\lambda/4$ resonator 6 with an expanded adapter opening 7 for a soundproof connection of the high-pressure adapter to the sound pressure level sensor 3 by means of a sealing ring 8. A mechanical compensation link 9 is integrated into the high-pressure adapter 2. In contrast to a rigid design of the high-pressure adapter 2, this compensation link simplifies the soundproof connection between the high-pressure adapter 2 and the sound pressure level sensor 3 if the components are not completely aligned. The sound pressure level sensor 3 remains in its structure 10 during calibration. For static pressure, the pistonphone volume 5 is ventilated via a resistance bore. The $\lambda/4$ resonator 6 is embodied as a tube with a constant diameter.

In pistonphone 1, the adjustable pistonphone volume 5 is sinusoidally compressed with frequency f by piston 4, and the $\lambda/4$ resonator tube is excited by the dynamic pressure fluctuations produced thereby. The high-pressure adapter 2 embodied as a

$\lambda/4$ resonator amplifies the sound pressure produced in the pistonphone volume and via its adapter opening 7 applies this amplified sound pressure to the sound pressure level sensor 3.

The adjustable pistonphone volume 5 and the length of the $\lambda/4$ resonator 6 can be tuned to one another by mechanical means such that the acoustic coupling effect and thus the amplification of the $\lambda/4$ resonator 6 is established at a maximum. The executed fine-tuning can be locked by mechanical means. The constructional means for executing tuning and locking are accessible to the person skilled in the art without requiring an inventive step and their embodiment is therefore not further described here.

The physical relationships (G1) to (G4) listed below may be used as an approximate basis for the design of the sound pressure level calibrator.

[see source for equation] (G1)

p_1	dynamic pressure in the pistonphone volume
χ	kappa air
p_o	static air pressure in the environment
s	piston area
l	piston amplitude (tip to tip)
V	pistonphone volume

[see source for equation] (G2)

P1	dynamic pressure on the sensor-side output of the $\lambda/4$ resonator
p_1	dynamic pressure in the pistonphone volume
f_A	excitation frequency on the piston
ρ	density of the air

L	length of the resonator tube
L_e	effective length of the $\lambda/4$ resonator (approximately 0.58 L)
R	radius of the $\lambda/4$ resonator
ν	dynamic viscosity of the air

[see source for equation] (G3)

P2	dynamic pressure at the membrane of the sound pressure level sensor
P1	dynamic pressure on the sensor-side output of the $\lambda/4$ resonator
d	diameter of the $\lambda/4$ resonator
D	diameter of the adapter opening

For a selected excitation frequency of $f_A = 314$ Hz, the above equations G1 to G3 can be used to estimate the sound pressure level P2 at the membrane of the sound pressure level sensor at : 152.8 dB re. 2E-5 Pa. The actual tube length, due to the additional spring effect of the pistonphone volume, which occurs parallel to the spring effect of the $\lambda/4$ resonator, must be designed greater than the tube length L theoretically resulting from the excitation frequency f_A, so that resonance occurs between the excitation frequency f_A and the vibration system. The actual tube length L for the $\lambda/4$ resonator results from the selected frequency f of the vibration system and the adaptation of the spring constant k2.

[see source for equation] (G4)

f	frequency of the vibration system at resonance
k1	spring constant of the pistonphone volume
k2	spring constant of the $\lambda/4$ resonator
M	vibrating mass of the $\lambda/4$ resonator

The control measurement of a sound pressure level calibrator designed in accordance with equations G1 to G4 for the selected excitation frequency $F_A = 314$ Hz resulted in a sound pressure level of 151.3 dB. This measured value is lower than the value of 152.8 dB resulting from equations G1 to G4, which is attributable to boundary and friction influences. However, the equations G1 to G4 reflect well the obtainable order of magnitude for the sound pressure level at the sound pressure level calibrator according to the invention.

The reproducibility of the sound pressure level calibrator according to the invention by means of a measurement series extending over 24 days results in a deviation from the mean value of the measured sound pressure level of approximately +/– 0.3 dB. These deviations are partly attributable to air pressure and temperature changes, which were not corrected when the measurement series was recorded.

The above measurement results for level amplification and reproducibility are determined with piezo transducers. If sound pressure level sensors with softer measurement membranes are calibrated, the achievable level amplifications will be somewhat lower.

The sound pressure level calibrator should be adjusted in the laboratory by means of a calibrated measuring chain, which corresponds to the sound pressure level sensor to be calibrated and has comparable installation conditions.